The Impact of Adapting a General Professional Development Framework to the Constraints of In-Service Professional Development on the Next Generation Science Standards in Urban Settings

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ABSTRACT: Urban school districts face a dilemma in providing professional development support for teachers in transition to the Next Generation Science Standards (NGSS). Districts need to maximize the quality and amount of professional development within practical funding constraints. In this paper, we discuss preliminary results from a researcher-practitioner partnership between Northwestern University and the Chicago Public Schools. We explore a model for quarterly NGSS professional development for urban middle school science teachers that spans three years. The workshop inquiry experiences are aligned to areas of research excellence at Northwestern. Teachers in twenty-three of the schools responded to a survey on the impact of formal and informal learning experiences on changes in teaching practice. We also analyzed the growth in student-rated inquiry-based science teaching practices. The results indicate that the professional development program had a significant direct impact on teaching practices as well as indirect impact on the teaching practices of other teachers at the school.

Keywords: professional development, science teaching, NGSS, middle schools

Urban school districts face a dilemma in providing professional development support for teachers in transition to the Next Generation Science Standards (NGSS). On the one hand, supporting shifts in teaching practice requires significant investment in professional development that is (1) long in duration, both in terms of total contact hours and in time span, and (2) involves the collective participation of school staff (Desimone & Garet, 2015; Garet, Porter, Desimone, Birman, & Yoon, 2001). Prior research has also shown that the direct benefits of professional development can also provide indirect benefits when teachers share what they have learned in professional development with other teachers at their school (Penuel, Sun, Frank, & Gallagher, 2012). On the other hand, frequent teacher turnover in urban settings creates barriers to schools' ability to reap the benefits of their professional development investment. Urban schools need to continually invest in new teachers. For example, less than half of Chicago teachers stay at the same school for more than four years (Allensworth, Ponisciak, & Mazzeo, 2009). Turnover is particularly acute for teachers in high poverty, low performing schools. This instability of the teaching corps tends to decrease curriculum coherence and the quality of instruction (Bryk, Sebring, Allensworth, Luppescu, & Easton, 2010). In addition, the small size of many schools in urban settings often means that there is only one teacher at the school in a given subject area, thus reducing the benefits that come from collective participation. In this paper, we discuss preliminary results from a researcher-practice partnership (RPP) between Northwestern

University and a network of Chicago Public Schools (CPS) elementary schools in which we are exploring a model for Next Generation Science Standards (NGSS) professional development that is uniquely adapted to an urban context.

Conceptual Framework

> *We need more information about specific aspects of [professional development] that are important in different contexts, in order to form a better understanding of why some [professional development] works and some doesn't.* (Desimone & Garet, 2015, p. 260)

This work is anchored in the literature on teacher professional development. In a recent review of professional development research, Desimone and Garet (2015) present a conceptual framework highlighting key features for designing professional development to positively impact teacher knowledge and changes in inquiry-based teaching. In addition to the two features listed above, high quality professional development also (3) is content focused, (4) involves active learning, and (5) is coherent with the school goals, teacher knowledge, the needs of students, and local policies. The content of professional development in science includes the disciplinary core ideas, science practices, and cross-cutting concepts that comprise the NGSS (NGSS Lead States, 2013). The active learning dimension incorporates four components: planning instruction, giving professional presentations, peer observation, and collaborative discussion. The latter two activities are often associated with professional community. The Desimone and Garet conceptual framework for professional development aggregates the prevalence of these four components of active learning into a single active learning scale. This active learning scale aggregates both individual and group activities. In addition, this active learning scale does not make a distinction between teachers collaborating with colleagues in their school or teachers collaborating with peers from other schools participating in the professional development.

Parise and Spillane (2010) extended the findings of Garet et al. (2001) by investigating how changes in teaching practice are differentially influenced by the indicators of professional community that are related to the Desimone and Garet (2015)'s active learning scale. Parise and Spillane (2010) labeled these indicators of professional community as on-the-job learning opportunities (i.e., peer observation, collaborative discussion, and advice seeking). They compared these indicators of professional community to formal learning opportunities, including professional development workshops, coursework, and network participation. Their study investigated these indicators for elementary math and English teaching in an urban setting, but not for science teachers. Of the various types of formal learning opportunities, content-specific professional development workshops significantly predicted self-reported changes in teaching practices, which is consistent with Garet et al. (2001). In contrast to Garet et al. (2001), Parise and Spillane (2010) found that a subset of the indicators of professional community directly predicted changes in teaching practices, specifically collaborative discussion and advice seeking. Likewise, McGee (2016) replicated the findings from Parise and Spillane, but in the discipline of science. He, too, found that collaborative discussion and advice seeking predicted self-reported changes in high school science teaching practice.

In addition to serving as a framework for the design of professional development, Desimone (2009) also presents the framework as a means to inform research on professional development. By relating the features of specific professional development programs to the framework, it becomes possible to aggregate the results of research across programs to draw conclusions on the effects of the various components on teacher knowledge and practice. In order to frame the design of our professional development program, we conducted an analysis of a small sample of impact studies on NGSS professional development programs. We used three sources, which resulted in eight studies. There is one study on science professional development cited in Desimone and Garet (2015); (see Penuel, Gallagher, & Moorthy, 2011). We became familiar with two programs presented at the 2016 and 2017 National Association of Researchers of Science Teaching annual meetings (see Reiser, Michaels, Dyer, Edwards, & McGill, 2016; Tuttle et al., 2016). Lastly, we used the search term "impact of NGSS professional development" in Google Scholar and limited the search to 2016-2017. An examination of the first two result pages yielded five more studies (see Capraro et al., 2016; Lotter et al., 2016; Minor, Desimone, Lee, & Hochberg, 2016; Taylor, Roth, Wilson, Stuhlsatz, & Tipton, 2017; Yoon et al., 2016). We characterized these studies according the Desimone and Garet framework (see Table 1).

Table 1: Characterization of a sample of science professional development programs by the dimensions of the Desimone and Garet framework

Study	Duration	Content Focus	Coherence	Active Learning	Collective Participation
Capraro	60 hrs/year for 3 years	Measurement, Math problem solving, motion and energy.	Focused on district needs	Design PBL modules	75 teachers from 3 high schools
Lotter	82 hrs/year	Energy, genetics, astronomy, geology	Locally developed units	Engage in inquiry lesson, practice teach inquiry lessons, group reflection	Statewide recruitment Teachers signed up individually
Minor	34 hrs/year for 2 years	Content related to one unit per grade level	Each unit aligned to district scope and sequence	Engage in inquiry lessons, collaborative discussion	Not described
Penuel	112 hrs	Big ideas in Earth Science	Aligned to district needs	Plan for instruction, collaborative discussion	Grade level teams from one district
Reiser	112 hrs	3-dimensional learning	Alignment to NGSS	Engage in inquiry lessons, Examine video cases of teaching practice	Teachers across a state were selected by local districts to participate locally
Taylor	88.5 hrs	4th grade: Earth processes, ecosystems 5th grade: Climate, water cycle	Aligned to state standards	Examine videos of others and own practice, design a unit	School teams across midrange districts in CO
Tuttle	80 hrs/year	One discipline per grade band	Aligned to NGSS	Engage in inquiry lessons, plan instruction	Recruited individually from an urban district

Yoon	40 hrs/year for two years	5 biology units	Focused on Complex systems	Engage in units, plan for instruction	10 teachers from 7 schools in a metropolitan area

A core feature of the framework is engaging teachers in professional development of sustained *duration*. While research does not point to specific guidelines for the length of professional development, Desimone and Garet (2015) have found that a minimum of 20 hours of professional development is needed to positively impact complex changes in teaching practice, such as inquiry-based science instruction. Amongst the sample programs reviewed, all of them provide more than 20 hours of professional development per year, with the minimum providing 34 hours in one year (Minor et al., 2016) and the maximum providing 112 hours in one year (Penuel et al., 2011; Reiser et al., 2016). Most of the sample programs provided more than 50 hours of professional development per year for multiple years.

Professional development should focus on specific *content* and be *coherent* with the needs of teachers and school districts. All of the sample programs focused on science content. Three of the sample programs indicated that they were working with specific school districts. Of those three, two indicated that the choice of science content was made in conjunction with the school district (Capraro et al., 2016; Penuel et al., 2011). Only one of those three programs indicated that the participating schools served primarily low-income students (Capraro et al., 2016). Of the programs that recruited teachers by region or statewide, only one provided a rationale for the selection of specific content, which was based on the goal of promoting systems thinking in biology (Yoon et al., 2016). Since the program recruited regionally, the teachers who joined presumably felt that the systems thinking content was coherent with their own goals. The other programs aligned their content to state or national standards.

The *collective participation* of school teams affords opportunities for teachers to more easily benefit from collaboration around the implementation of what was learned in the professional development. Only three projects specifically mentioned that teachers were recruited as school teams to participate in the workshops (Capraro et al., 2016; Penuel et al., 2011; Taylor et al., 2017). In the cases of Capraro et al. (2016) and Penuel et al. (2011), the professional development was conducted in conjunction with specific school districts. While not explicitly mentioned, the size of the teacher population and participation by school teams implies that teachers in these two projects were expected to participate in the professional development. All of the other programs seemed to recruit teachers on a voluntary basis, which means they are more likely to be actively engaged and reap the benefits of the program since they chose to participate.

The modes of engaging teachers in *active learning* varied. Some programs provided teachers with instructional materials. These programs prepared teachers by having them engage in the activities and then plan for how they would implement those activities in their own classroom (Lotter et al., 2016; Minor et al., 2016; Penuel & Gallagher, 2009; Yoon et al., 2016). Other programs engaged teachers in lesson/unit development (Capraro et al., 2016; Penuel & Gallagher, 2009; Tuttle et al., 2016). A handful of programs engaged teachers in reflection on videos of science teaching practices (Reiser et al., 2016; Taylor et al., 2017). In general, professional development programs, such as these, influence teachers' knowledge and skills, which in turn influence teaching practices (Desimone, 2009).

Professional Development Needs of Urban Districts

Desimone and Garet (2015) caution the field that the professional development needs of urban districts provide unique challenges for their framework. The high turnover of teachers and principals in urban settings creates challenges for both implementing and conducting research on professional development programs in urban context. Of the sample of recent studies we reviewed on impact of NGSS professional development programs, only one specifically targeted a low-income context (Capraro et al., 2016). The program had unusually high teacher retention, with most of the sample of 75 teachers across three high schools completing the three-year program. However, the researchers had to drop one-fourth of the student sample since they were not in the same high school for the three-year study. In their section on the challenges of urban professional, Desimone and Garet (2015) did not cite any studies on professional development in urban settings. We need to find ways to design, implement, and conduct research on professional development programs that do not ignore our most vulnerable students.

NU Leadership Academy Professional Development Model

In our CPS context, high teacher turnover, the small size of neighborhood schools, and the fiscal crisis in IL create barriers to realizing the duration, coherence, and collective participation that is consistent with other science professional development programs, as represented by the sample programs reviewed in this paper. All of the programs reviewed here included a summer professional development experience. The cost to CPS for summer stipends alone for the targeted network of schools would be over $100,000. On average, about $20,000 of that investment would be lost at the end of each year when one-fifth of the teachers leave the schools. In addition, anecdotal conversations with our teachers indicate that many of them use the summer to decompress from the intensity of their work environment and refuse to participate in summer professional development. The timing and duration of the workshop experiences need to provide a sustainable model for urban districts. Our professional development includes quarterly one-day, seven-hour workshops during school days. Each participating school is responsible for funding the substitute teacher. The combination of reducing the number of hours and shifting of costs from stipends to subs significantly reduces the costs for the district in comparison to a summer program. If CPS feels that the model is successful, it could easily be adapted to fit the context of the ongoing quarterly in-service professional development days, which would reduce the costs even further. At 28 contact hours per year, our program is above the 20-hour benchmark recommended by Desimone and Garet (2015), but 20% below the shortest duration program reviewed above.

Frequent teacher turnover also creates barriers to maintain coherence across years of a professional development program. Several of the programs reviewed here are multi-year programs that are cumulative. Those programs seemed to benefit from settings with a stable cadre of teachers or perhaps, the voluntary nature of the professional development attracts teachers who are more likely to stay at their schools. In a context like Chicago, a coherent program is one that can provide an accumulation of knowledge and skills for those that participate across multiple years, but each session is also stand-alone such that teachers can join the program at any point. In addition, the sustained fiscal crisis in Chicago has prevented schools from replenishing science curricula for almost a decade. Therefore, a coherent program needs to support implementation of freely available resources across the widest possible topic areas within the duration constraints. This model of coherence seems to contrast with those programs reviewed here, in which the focus was fewer topic areas in greater depth. It is likely that the middle- to upper-income districts that are typically the target of science professional development research already have current science curricula in place and can benefit from a deep focus in a subset of the school year curriculum.

The NU Leadership Academy model is a three-year professional development program targeted at the middle school teachers in a network of thirty-three K-8 elementary schools in CPS. The student population in this network is 95% African American and 90% low-income as indicated by participation in free and reduced price lunch programs. For most of the schools in the network, there is only one middle school teacher who teaches 6th, 7th, and 8th grade science. We were able to secure funding from the Fry Foundation and the Toyota Foundation to cover the expenses of planning, implementing, and evaluating the quarterly professional development program. Through this cohort model, teachers had the opportunity to collaborate with teachers at other schools serving similar populations of students. While not from the same school, this model has the potential to provide some of the benefits of collective participation. The schools provided the funds for substitute teachers. This shared cost model also placed an incentive for principals to hold teachers accountable for implementing what was learned. We also have anecdotal evidence that some principals required teachers to attend the professional development workshops. Therefore, we ended up with a mixture of volunteers and "voluntold" participants.

We discussed three criteria for the selection and sequence of topics to maximize coherence within the duration constraints. First, the workshop topics align to the district's science scope and sequence, such that the middle school teachers participate in workshops in preparation for the NGSS performance expectations to be addressed in that quarter. Second, the workshops focus on one grade level each year, with 7th grade life science in 2015-16, 6th grade Earth science planned for 2017-18, and 8th physical science planned for 2018-19. Since there is primarily one teacher for the three grade levels, teachers who remain in their school for the three years will benefit from the accumulated experience of sixteen NGSS-related workshops over three years. For schools where there is teacher turnover, new teachers can join the series and still productively participate since each year and each workshop stands alone. In addition, we identified those teachers who consistently participated in workshops and who provided evidence that they were implementing was learned. These active participants were invited to become co-designers and co-facilitators of subsequent workshops as a way to develop capacity within the network to sustain the workshops in future years. Third, the targeted workshop topics also align to the areas of research excellence at Northwestern University. Science and engineering graduate student researchers from those areas of excellence worked with us to create research experiences for workshop participants. These research experiences provide a model for specific units that teachers can implement. In addition, these inquiry-based activities challenge the middle school teachers' understanding of core disciplinary ideas and scientific practices in NGSS.

For example, in the first quarter of the district's 7th grade life science scope and sequence, the focal disciplinary core ideas are related to *From Molecules to Organisms: Structures and Processes*. Within that broad DCI, there was one performance expectation that aligned to a neuroscience program at the university. MS-LS1-8 focuses on gathering and synthesizing information about how sensory receptors send messages to the brain for immediate behavior. Two neuroscience graduate students worked with us to design the workshop experiences. In the investigation, teachers used a web-based reaction time system to design experiments to explore factors that affect reaction time (http://cognitivefun.net/test/1). For example, teachers examined gender, dominant vs non-dominant hand, and with vs. without glasses. These experiments provided the backdrop for gathering and synthesizing information about a particular neurological disease, Guillain-Barré Syndrome. Teachers provided an explanation for how the disease would impact messages from the sensory receptors and affect reaction time. After completing the investigation, the teachers were provided time to develop plans for implementing the investigation with their students. The workshops in subsequent quarters followed a similar pattern for topics in genetics, ecology, and evolution. While the specific science and engineering practices and cross-cutting concepts varied depending on the target performance expectations, we maintained a focus on science explanation as a core practice as well as implemented the network's overall teaching strategies related to reading-to-learn.

In this study, we sought to investigate what level of impact our professional development model had on teachers' practices as self-reported by the teachers as well as reported by the students. Desimone (2009) recommends that professional development researchers also measure changes in teacher content knowledge and pedagogical content knowledge as mediators of changes in teaching practice. However, given the variability of participation in the workshops across the thirty-three schools and the limited resources of the professional development program, it was not viable to measure changes in teacher knowledge. Desimone (2009) also recommends that professional development programs measure the impact of changes in teaching practice on student learning. At the time of this study, the state of IL was in transition to a new NGSS-aligned assessment. Therefore, there was no state student science assessment administered during the timeframe of this study. However, research similar to Parise and Spillane (2010) has shown that self-reported changes in teaching practice are predictive of improvements in student learning (Supovitz, Sirinides, & May, 2010). Therefore, this study focuses solely on the impact of participation in the professional development on teaching practices. The time frame of this study extends from the 2012-13 school year, which is the year before the schools were formed into a network, through the 2013-14 school year, when we pilot tested a version of the model, to the 2015-16 school year, which was the first year of the current model focusing on 7th grade life science topics. (The 2014-15 school year was a gap in the implementation of the model.) This study will address the following research questions:

- Does the level of participation NU Leadership Academy predict changes in teaching practice?
- Does active participation in the NU Leadership Academy provide indirect benefit to other teachers at the schools where active participants teach?

Methods

In this research, we investigate whether the level of participation in the workshops influenced teachers' changes in teaching practices, both self-reported and as reported by students. Our approach parallels the research design used by Parise and Spillane (2010). They extended the findings of Garet et al. (2001) by investigating how changes in elementary math and English teaching practice are differentially influenced by formal and informal professional learning opportunities. Parise and Spillane examined the impact of coursework, professional development and participation in outside networks. Of these various types of formal learning opportunities, only content-specific professional development significantly predicted changes in teaching practices, which is consistent with Garet et al. (2001). Parise and Spillane also examined informal professional learning opportunities (i.e., peer observation, collaborative discussion, and advice seeking) and found that the extent to which teachers engaged in collaborative discussion with colleagues and sought advice from colleagues predicted changes in teaching practice. In previous research in CPS, we replicated the findings of Parise and Spillane in the absence of any external professional development program for high school science departments in a network of CPS high schools (McGee, 2016).

Measures

There are two sources of outcome data about teaching practices. The first source is a variation of *School Staff Questionnaire* used in Parise and Spillane (2010). The survey was administered at the end 2015-16 school year and only addresses the impact of the first year of the program on teaching practices. In addition, we gathered district data about the level of inquiry-based science teaching as reported by students on the district's *5 Essentials* questionnaire (Bryk et al., 2010). These data cover the timespan of the whole study period from 2012-13 to 2015-16.

School Staff Questionnaire. This questionnaire was adapted from Parise and Spillane (2010). The questionnaire contains the dependent variable related to self-reported changes in teaching practice. The independent variables distinguish between the level of participation in formal and informal professional learning opportunities. The formal professional learning opportunities items include participation in workshops, graduate coursework and participation in networks. By asking teachers in general about the amount of workshop participation it allows us to capture not only participation in the NU Leadership Academy workshops, but also other professional development opportunities that may be available. The level of network participation provides an indicator of the extent to which teachers may view their participation in the NU Leadership Academy as a form a collective participation.

While the NU Leadership Academy did not provide specific supports for informal professional learning at the schools, our prior research in Chicago indicates that there is a prevalence of informal learning occurring in CPS schools without specific external supports (McGee, 2016). In addition, by surveying other teachers at the schools, primarily K-5 teachers, we can address our second research question on the extent to which there are indirect benefits to other teachers at the school. The informal professional learning constructs are collaborative discussion, peer observation, and advice seeking. The questionnaire also includes control variables related to teacher demographics. The survey contains twenty-six questions, which took about 15 minutes to complete.

Changes in science teaching practices scale (dependent variable). The dependent measure is a scale comprised of eight questions about the extent to which teachers changed their science teaching practice in the past year on a seven-point scale for the following aspects of science teaching: (1) student assessment, (2) student grouping, (3) materials used, (4) topics covered, (5) teaching methods used, (6) kinds of work students do, (7) kinds of questions asked, and (8) understanding the needs of individual students in their class. The items were averaged to create the changes in science teaching practices variable, which served as a dependent variable for this study. The alpha reliability of the changes in science teaching practices variable was 0.93.

Formal professional learning opportunities (independent variables). There were three questions about formal professional learning opportunities. First is frequency of participation in science professional development workshops in the last year. The answer options for workshops are on the following scale: None (1), 1-2 sessions (2), 3-4 sessions (3), 5-7 sessions (4), and 8+sessions (5). Second is the number of science or science education courses taken in the last year. The answer options for science coursework are on the following scale: None (1), 1 class (2), 2 classes (3), 3 classes (4), and 4+ classes (5). Third is the frequency of outside network participation in the last year. The answer options for network participation are on the following scale: Never (1), 1-2 times (2), 3-4 times (3), and 5+ times (4). Each question will be used separately as an independent variable.

Informal professional learning opportunities (independent variables). There were three constructs related to the prevalence of informal professional learning opportunities: collaborative discussion, peer observation, and advice seeking. To capture the range of informal professional learning opportunities, each construct contains multiple questions that form into a scale. All of the answer options are on the following scale: Never (1), A few times per year (2), Monthly (3), Weekly (4), and Daily (5).

The collaborative discussion dimension contains seven questions that measure the self-reported frequency with which teachers engage in conversation with colleagues regarding teaching and learning: (a) what helps students learn the best, (b) development of new curriculum, (c) the goals of this school, (d) managing classroom behavior, (e) science instruction, (f) content or performance standards in science and (g) collaborative review of student work. The alpha reliability of the collaborative discussion scale as a whole was 0.87.

There were three questions about the frequency with which teachers engage in peer review and feedback. The alpha reliability of the peer observation and feedback scale was 0.80.

There was one question related to science advice seeking. Teachers were asked, "To whom do you turn for advice or information about science instruction?" Respondents could list up to ten different individuals who served as sources of advice. As an indicator of strength of the relationship with each advice giver, teachers were also asked to indicate how often they turned to each source for advice, ranging from *yearly* to *daily.* The science advice seeking measure is created by totaling the frequency with which advice was sought from all sources listed. The science advice giving construct is created by totaling the frequency with which others sought advice from a teacher.

Teacher characteristics (control variables). There were five questions about individual teacher characteristics, which were included as control variables in the analyses, including age, number of years as a teacher, number of years teaching at the current school, gender, and race.

Inquiry-based Science Instruction Scale. Each year, the 5 Essentials survey is administered to every teacher in CPS and to every middle school and high school student in CPS. The overall survey addresses a variety of school climate topics. Within the overall *5 Essentials* survey for students, there is an Inquiry-based Science Instruction scale. Students report the frequency to which they: use laboratory equipment or specimens, write lab reports, generate your own hypotheses, use evidence/data to support an argument or hypothesis, and find information from graphs and tables. The answer options are on the following scale: Never, Once or twice a semester, Once or twice a month, Once or twice a week, and Almost every day. Researchers at the University of Chicago use hierarchical linear scaling to develop a scale score for each school along the following range: Very Weak (1), Weak (2), Neutral (3), Strong (4), and Very Strong (5). The survey scale has been validated to predict growth in ACT performance (Allensworth, Correa, & Ponisciak, 2008).

Population

During the months of May and early June 2016, we used two approaches for administering the *School Staff Questionnaire.* In the first approach, all of the middle school teachers who attended the fourth quarter workshop in spring 2016 completed the survey online at the end of the workshop experience. In addition, the teachers were provided with a package of paper surveys. They were asked to distribute the surveys to the K-5 teachers at their school, collect the completed surveys, and mail the package back to the network office. For schools that did not have a teacher attend the fourth quarter workshop, packages of paper surveys were sent to the middle school teachers. They were asked to complete a survey, distribute surveys to the K-5 teachers at their schools, collect the completed surveys, and mail the packages back to the network office. The teachers who were provided with the surveys at their schools also had the option of completing the survey online.

The teachers in this study come from 23 of 33 schools in the network. A total of 93 teachers responded to the survey. Thirty (30) middle school science teachers at the 23 schools responded to the survey, reflecting that some schools have more than one middle school science teacher. Of the middle school teachers, 12 were active participants in the workshops during the 2015-16 and 18 did not actively participate in the program. These 12 active participants engaged in more than 20 hours of professional development, which is above the Desimone and Garet (2015) threshold. Sixty-three (63) K-5 teachers out of roughly 560 K-5 teachers at the 23 schools responded to the survey (12% response rate). These K-5 responses are distributed across both schools with active participants and those without active participants. The significantly higher response rate for middle school teachers versus elementary teachers reflects the fact that the intervention was targeted at middle school teachers. However, even though the K-5 teacher response rate was low overall, there are a sufficient number of respondents to allow us to draw conclusions about the indirect benefits of the middle school professional development on K-5 teachers.

Three-fourths of the teachers identified as African American (74%) and about one-fifth identified as Caucasian (22%). The remaining teachers identified as Hispanic (3%), and Other (4%). Ninety-one percent of the teachers were female (91%). The distribution of overall teaching experience is skewed towards teachers with more than 10 years of experience (63%). The median years of teaching experience was 15 years (see Table 2). However, the distribution of experience at the current school was skewed toward the lower end, with half of the teachers at their school for five years or less (51%) and the median years at the current school was 5 years. This discrepancy between overall teaching experience and experience at the current school suggests that the population reflects the high turnover rate typical of urban districts (Allensworth et al., 2009).

Table 2: Years of Teaching Experience

	At School	Total
1-5 yrs	46	12
6-10 yrs	21	21
11-15 yrs	10	21
16-20 yrs	8	22
> 20	3	15

Results

Table 3 compares the descriptive statistics between the elementary teachers and the middle school teachers for the primary dependent and independent variables included in this study. For each variable, we conducted a one-way ANOVA to test the statistical significance of the mean differences by group. The dependent variable—changes in science teaching—indicates that, on average, elementary teachers were slightly below the midpoint of 4 on the scale. Middle school teachers who were active participants were statistically more likely to have made changes to their teaching practice at 6 on a 7-point scale ($F(2,85)=12.5$; $p<0.0001$). Non-active middle school teachers averaged at midpoint. In terms of formal professional learning opportunities, elementary teachers on average participated in 1-2 science workshops. Active middle school teachers on average attended 5-7 science workshops, whereas non-active middle school teachers on average attended 3-4 science workshops ($F(2,88)=32.9$; $p<0.0001$). In addition, active middle school teachers were more likely to report participation in outside network activities between 3 to 4 times per year on average ($F(2,90)=45.3$; $p<0.0001$). These results provide evidence that active teachers may be viewing the cohort-based workshops as an opportunity to collaborate with teachers across schools and to possibly accrue some of the benefits of collective participation.

Both active and not active middle school teachers were more likely to engage in collaborative conversations with their colleagues (about once per month), than elementary teachers (between a few times per year and once per month) ($F(2,90)=4.9$; $p=0.01$). There was no statistically significant difference between elementary and middle school teachers on the frequency of advice seeking or peer observation and feedback. However, there was a statistically significant difference in the extent to which active middle school teachers were sought out for advice by colleagues ($F(2,90)=3.3$; $p<0.05$). Active middle school teachers were more than twice as likely to be sought out for advice.

Table 3: Descriptive statistics for the dependent and independent variables

Variable	Elementary	Middle School	Middle School Active	p value
N	61	18	12	
Dependent Variable				
Changes in science teaching	3.4	4.0	6.0	0.000
Formal Learning Opportunities				
Science professional development	1.7	2.6	4.0	0.000
Science Coursework	1.2	1.2	1.4	ns
Network participation	1.4	1.9	3.5	0.000
Informal Learning Opportunities				
Conversations with colleagues	2.6	3.0	3.2	0.01
Science Advice Seeking	2.7	2.5	3.7	ns
Give Science Advice	1.0	0.4	2.3	0.04
Peer Observation and Feedback	1.1	1.4	1.3	ns

Regression Results of School Staff Questionnaire

As indicated above, this research parallels the work of Parise and Spillane (2010). Therefore, we followed their analytic strategy for modeling the impact of formal and informal learning opportunities on changes in teaching practices. We used multiple stepwise regression to independently examine the influence of formal learning and informal learning opportunities on changes in teaching practice and then examined the combined influence of both formal and informal learning opportunities. All of the variables for a given model were entered into the regression. The variable that provides the most information is added to the equation and the regression is run again to add the variable that provides the next most amount of information until the equation includes only variables that are statistically significant. Table 4 shows the variables that were included for each of the three models. Variables that were not entered into the model are indicated as NS for not significant.

The regression model for Formal Learning Opportunities was statistically significant ($F(1,82)=64.13$; $p<0.001$; $R^2 = 43\%$). The only statistically significant variable was the extent to which teachers participated in science professional development. The regression model for Informal Learning Opportunities was statistically significant ($F(2,85)=16.33$; $p<0.001$; $R^2 = 26\%$). There were two statistically significant variables. The extent to which teachers engaged in conversations about science influenced teachers' science teaching practice. Consistent with prior research showing the indirect benefits of professional development, advice seeking at schools with an active middle teacher was associated with changes in science teaching practice. The combined model was statistically significant ($F(3,79)=32.71$; $p<0.001$; $R^2 = 54\%$). Attendance at professional development and school-based conversations were statistically significant. Advice seeking at schools with an active middle school teacher was not statistically significant in the combined model. However, when accounting for variability in science professional development attendance, the conversations at schools with active middle school teachers had additional influence on changes in science teaching.

Table 4: Results of Multiple Regression of Variation of Learning Opportunities on Changes in Science Teaching Practice

	Changes in Science Teaching Practice		
Independent Variable	Formal Learning Opportunities Only	Informal Learning Opportunities Only	Full Model
Formal Professional Opportunities			
Science Professional Development	**0.52****		**0.56****
PD X Grade Level	NS		NS
Science Courses (School Year)	NS		NS
Outside Network Participation	NS		NS
Informal Professional Opportunities			
Conversations about science		**0.48****	**0.27****
Conversations @ Active School		NS	**0.16***
Advice Seeking		NS	NS
Advice Seeking @ Active School		**0.19***	NS
Peer observation and feedback		NS	NS
Teacher Controls			
Years Teaching at Current School	NS	NS	NS
Gender, Race	NS	NS	NS
R-square	43%	26%	54%
Observations	84	88	83

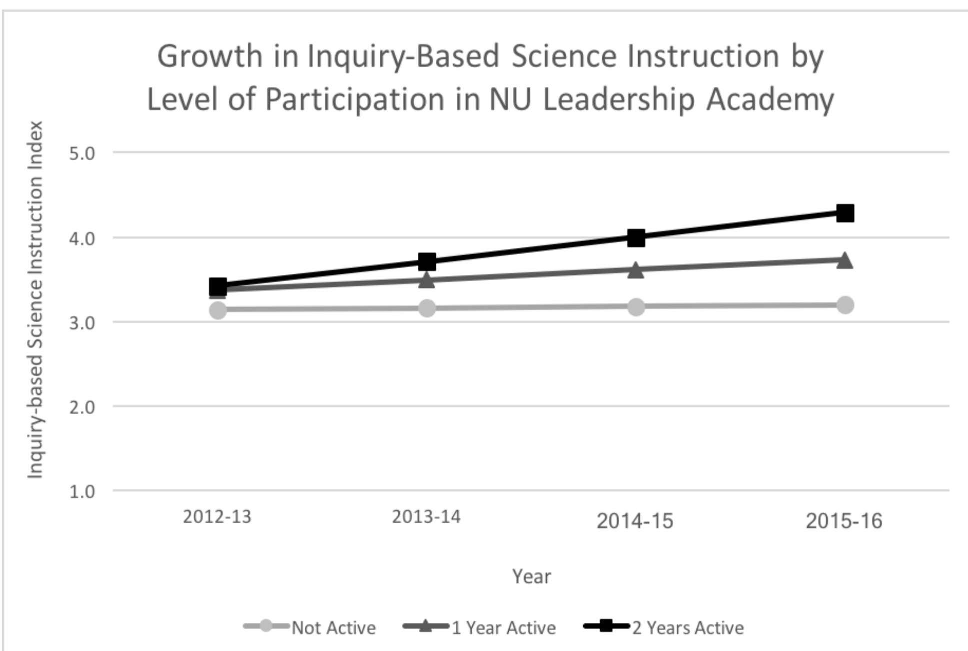
Significance Levels: 0.05 = *; 0.01 = **; NS = not significant

Growth of Science Teaching Practices by Level of Workshop Participation

The regression results of the School Staff Questionnaire show that level of participation in in one year of professional development influenced the amount of self-reported changes in teaching practices over the course of one year. To corroborate those findings, we conducted an analysis of the influence of workshop participation on the year over year changes in inquiry-based science teaching as rated by the students. This analysis included the school level aggregate ratings for all thirty-three elementary schools in the network over four years. The 2012-13 school year serves as a baseline since it is the year before the schools in CPS were reorganized into new networks. We provided a pilot version of the professional development program in 2013-14 and the first year of the full model in 2015-16. The 2014-15 school year was a gap year for the professional development intervention. Schools were categorized as active in a given year if the schools sent teachers to more than half of the workshops that year, even if the school sent different teachers to different workshops. By shifting the analytic approach from the individual teachers to the school level effects, it allows us to analyze the impact of the program despite teacher turnover.

Given that there were four measurement occasions for each of the schools, we used a hierarchical linear model to analyze changes in student rated inquiry-based science teaching. The measurement occasions served as the level 1 variable. The level of active participation at the school level (none, 1 year, 2 years) served as a level 2 variable. The baseline growth model was not statistically significant ($t(32)=1.7$; ns). There was an interaction effect between the growth curve and the number of years that a school actively participated in the NU Leadership Academy ($t(32)=3.9$; $p<0.001$). The addition of level of participation into the model reduced the variance around the slope of the growth in inquiry-based science teaching by 10%. Each year of active participation increased the growth rate by 0.15 points on the index, such that schools that were active for both years grew at a rate of 0.30 points per year over the course of the study period. There was no statistically significant difference in the inquiry-based science teaching scale in the baseline year. Figure 1 provides a graphical display of these results. The graph was generated based on the average intercept and slope for each condition.

Figure 1



Discussion and Conclusion

In this research, we developed a professional development model based on Desimone and Garet (2015) that addressed the unique constraints of urban contexts. The levels of high teacher turnover, the small size of neighborhood schools, and the fiscal crisis in IL create barriers to fully realizing the duration, coherence, and collective participation dimension in urban contexts. In order to minimize the costs of the program to the district, we provided quarterly school year workshops such that the number of hours per year was above the threshold of 20 hours, but 20% below comparable models. To foster coherence, we aligned the quarterly workshops to the specific performance expectations that teachers were expected to be teaching around the time of the workshop. The workshops were designed to provide teachers with experience on specific lessons to be implemented. The workshop experiences were designed to focus on explanation as a core practice, thus enabling the accumulation of knowledge across workshops. At the same time, each workshop was designed to be stand-alone so that new teachers could join the program at any point.

In this research, we sought to investigate whether the level of participation the NU Leadership Academy influences changes in teaching practice. The results of analysis of the School Staff questionnaire showed that teachers who were active participants in the academy participated in more professional development overall than other middle school teachers and K-5 teachers in the same network. The level of participation in professional development was indeed a significant predictor of self-reported changes in teaching practice. All teachers in CPS had access to other general professional development about NGSS, which also had an impact on their changes to teaching practice, but to a lesser degree. We also examined whether participation in the academy workshops influenced the extent to which teachers changed their teaching practices over time as rated by the students. Over the course of three years, schools that have active participants in both years of the academy saw a statistically significantly higher growth rate in inquiry-based teaching practices. They went from a neutral rating of inquiry-based teaching practices to a strong rating over the course of three years.

In addition to analyzing the direct benefits of the program, we also investigated the indirect effects of the professional development program on other teachers at schools with active participants. After controlling for the effects of formal professional development workshops, all teachers benefited from collaborative conversations. However, collaborative conversations at schools that had a middle school teacher who actively participated in the academy had a greater influence on changes in teaching practice. In addition, the teachers who actively participated in the academy were more likely to be sought out for advice, which is consistent with prior research indicating that teachers with specific expertise are more likely to be sought out for advice (Spillane, Hallett, & Diamond, 2003). These results provide evidence that there are indirect benefits of workshop participation to improve teaching practices for teachers who did not engage in the workshop.

This research points to the promise of engaging teachers in economical professional development using a framework of best practices in professional development to design professional development that addresses the unique barriers faced by urban school districts. While more professional development would likely lead to more significant changes in teaching practice, there are practical constraints in urban settings. These results provide evidence that school districts can develop a coherent program of science professional development experiences that fit within their existing in-service professional development framework.

Our future research will continue to track the development of teaching practices as teachers continue in the program for additional years. In addition, future research would benefit from direct measures of changes in teacher knowledge as a mediator of changes in teaching practice as well as the impact of changes in teaching practice on student learning outcomes.

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